NEWLY IDENTIFIED LINES OF Ni XVIII, Cu XIX, AND Zn XX

IN THE SODIUM I ISOELECTRONIC SEQUENCES

by

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ABSTRACT

Lines are reported belonging to Ni XVIII, Cu XIX, and Zn XX for the following transitions:

$3s\,^2S - 4p\,^2P^\circ$, $3p\,^2P^\circ - 4s\,^2S$, $3p\,^2P^\circ - n_1\,d\,^2D$ $(n_1 = 4,5)$

and $3d\,^2D - n_2\,f\,^2F^\circ$ $(n_2 = 4,5,6)$.

Wavelengths, energies and term values are given.

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INTRODUCTION

With the use of a low inductance vacuum spark between electrodes made of the elements under investigation, we have recorded lines of highly-ionized Ni, Cu, and Zn in the region 25Å - 53Å. The low inductance discharge circuit consisted of a 14μf capacitor charged to 12 kv and triggered by the discharge of a tesla coil placed near the ground electrode. The spectra were recorded on Kodak SWR glass plates using a modified Jarrell-Ash 3-meter, 88° angle of incidence spectrometer. The grating was a 1200 line per mm Bausch and Lomb gold replica, blazed at $2^{\circ}35'$. As reference lines we used lines of highly ionized C, O, Ni, and Cu.

SODIUM I ISOELECTRONIC SEQUENCE

Edlén[1] has measured and classified lines of ions in the Na I isoelectronic sequence, up to Co XVIII, for the following transitions: $3d\,^2D - nf\,^2F^o$, $3p\,^2P^o - nd\,^2D$, $3p\,^2P^o - ns\,^2S$, and $3s\,^2S - np\,^2P^o$, where n is usually 4, but sometimes is 5 or 6. He obtained the wavelengths of the $3p\,^2P^o - 4d\,^2D$ and $3d\,^2D - 4f\,^2F^o$ transitions of Ni XVIII. For the Cu XIX spectrum he gives the wavelength of the $3d\,^2D - 4f\,^2F^o$ transition, but not of the $3p\,^2P^o - 4d\,^2D$ transition. The latter transition was, however, present in his Cu spectrum. (Figure 2 of his paper).

We have identified lines as belonging to Ni XVIII, Cu XIX, and Zn XX. (Table I). The lines are due to the following transitions: $3s\,^2S - 4p\,^2P^o$, $3p\,^2P^o - 4s\,^2S$, $3p\,^2P^o - n_1 d\,^2D$ ($n_1 = 4,5$), and $3d\,^2D - n_2 f\,^2F^o$ ($n_2 = 4,5,6$). In order to construct a term value scheme, it is necessary to know the differences between the $3s\,^2S_{1/2} - 3p\,^2P^o_{1/2,3/2}$ and $3p\,^2P^o_{1/2,3/2} - 3d\,^2D_{3/2,5/2}$ energy levels. We were not able to observe these transitions on our Ni, Cu, and Zn plates. In fact, no experimental

data have been reported for these transitions for members of the isoelectronic sequence above Ca x. Cn the one- electron spectra in which no s electron is involved, the selection rules indicate three allowed transitions from one configuration to the other. Two of these lines, in which $\Delta L = \Delta J$, are expected to be much more intense than the third. Furhtermore, in some cases the splitting $\Delta\nu\ (nL_{L-1/2} - nL_{L+1/2})$ (n = 4,5,6) is close to the resolving power of the spectrometer at this particular wavelength making it difficult to resolve the lines. This accounts for our inability to identify the third line of each transition. For these reasons we had to include in our scheme extrapolated values of the energies of the $3p\,^2P^{\circ}_{1/2,3/2}$, and $3d\,^2D_{3/2,5/2}$ levels. For Ni XVIII and Cu XIX Edlén's extrapolated energies have been used; for Zn xx we extended the extrapolation. Term values are given in Table II.

It appears from our measurements that the wavelength 44.348Å given by Edlen for $3p\,^2P^{\circ}_{3/2} - 4d\,^2D_{5/2}$, in Ni XIX, should be changed to 44.365Å.

The $3d\,^2D - 5f\,^2F^{\circ}$, $3d\,^2D - 6f\,^2F^{\circ}$, and $3p\,^2P^{\circ} - 5d\,^2D$ transitions of Co XVII were also present on our plates. Their wavelengths and energies, not reported by Edlén, are given in Table I and II, respectively.

The calculation of the limit $2s^2 2p^6\ ^1S_0$ in Zn xx was based on the $^2F^{\circ}$ energy levels. Recalculating the limits for Ni XVIII and Cu XIX using the new data, we conclude values given by Edlèn require at most a slight revision upwards. We have retained his values, however, since they are within the range of our experimental error.

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TABLE 1- Newly Identified Lines In The Na I Isoelectronic Sequences

TRANSITION	Co XVII $\lambda(\mathring{A})$	Co XVII In	Co XVII $\nu(cm^{-1})$	Ni XVIII $\lambda(\mathring{A})$	Ni XVIII In	Ni XVIII $\nu(cm^{-1})$	Cu XIX $\lambda(\mathring{A})$	Cu XIX In	Cu XIX $\nu(cm^{-1})$	Zn XX $\lambda(\mathring{A})$	Zn XX In	Zn XX $\nu(cm^{-1})$
3d $^2D_{5/2}$ - 4f $^2F^o_{7/2}$				52.720*	8	1896800*	47.437*	8	2108060*	42.93	8	2329400
$^2D_{3/2}$ - $^2F^o_{5/2}$				52.615*	7	1900600*	47.329*	7	2112870*	42.83	7	2335100
3p $^2P^o_{3/2}$ - 4s $^2S_{1/2}$				51.04	3	1959200	46.08	3	2170100			
$^2P^o_{1/2}$ - $^2S_{1/2}$				50.25	3	1990000						
3p $^2P^o_{3/2}$ - 4d $^2D_{5/2}$				44.365	7	2254000	40.26B	7	2483800	36.74	7	2721800
$^2P^o_{1/2}$ - $^2D_{3/2}$				43.814*	5	2282400*	39.72	5	2517600	36.20	5	2762000
3s $^2S_{1/2}$ - 4p $^2P^o_{3/2}$				41.24	4	2424800	37.50	3	2666700	34.27	3	2918000
$^2S_{1/2}$ - $^2P^o_{1/2}$				41.03	6	2437200	37.30	6	2681000	34.08	6	2934300
3d $^2D_{5/2}$ - 5f $^2F^o_{7/2}$	41.462*	4	2411800	37.08	4	2696900	33.33	4	3000300	30.14	3	3317900
$^2D_{3/2}$ - $^2F^o_{5/2}$	41.40	3	2415600	37.02	3	2701200	33.27	3	3005700	30.08	2	3324500
3p $^2P^o_{3/2}$ - 5d $^2D_{5/2}$	35.92	4	2784000	32.34	4	3092100	29.29	4	3414100	26.62	3	3756600
$^2P^o_{1/2}$ - $^2D_{3/2}$	35.61	2	2808200	32.04	2	3121100	29.00	2	3448500	26.33	1	3797500
3d $^2D_{5/2}$ - 6f $^2F^o_{7/2}$	35.69	3	2801900	31.87	2	3137700	28.65	2	3490400			
$^2D_{3/2}$ - $^2F^o_{5/2}$												

* - From Edlén's data

B - Blurred due to the C v line 40.270Å

TABLE II - Energy Scheme For Terms In The Na I Isoelectronic Sequences

Config.	Desig.	J	Co XVII Level (cm^{-1})	Co XVII Interval (cm^{-1})	Ni XVIII Level (cm^{-1})	Ni XVIII Interval (cm^{-1})	Cu XIX Level (cm^{-1})	Cu XIX Interval (cm^{-1})	Zn XX Level (cm^{-1})	Zn XX Interval (cm^{-1})
3s	3s ^2S	1/2			0		0		0	
3p	3p $^2P^o$	1/2			310600*	30400	327700*	36100	344700	42900
		3/2			341000*		363800*		387600	
3d	3d ^2D	3/2			766700*	4600	812300*	5800	858700	7200
		5/2			771300*		818100*		865900	
4s	4s ^2S	1/2			2300200		2533900			
4p	4p $^2P^o$	1/2			2424800	12400	2666700	14300	2918000	16300
		3/2			2437200		2681000		2934300	
4d	4d ^2D	3/2			2593000*	2000	2845300	2300	3106700	2700
		5/2			2595000		2847600		3109400	
4f	4f $^2F^o$	5/2			2667400*	800	2925200	1000	3193800	1500
		7/2			2668200*		2926200		3195300	
5d	5d ^2D	3/2	3101800	1100	3431700*	1400	3776200	1700	4142200	2000
		5/2	3102900		3433100		3777900		4144200	
5f	5f $^2F^o$	5/2	3137100	100	3467900	300	3818000	400	4183200	600
		7/2	3137200*		3468200		3818400		4183800	
6f	6f $^2F^o$	5/2								
		7/2	3527100		3909000		4308500			
$2s^2 2p^6$ $^1S_0$	Limit				4897400*		5410000*		5952000	

FOOTNOTE

[1] B. Edlén, Z. Phys. 100, 621 (1936).